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Purcell et al.

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(54) **MEMORY SYSTEM**

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H05K 7/18 (2006.01)

(52) **U.S. Cl.**
USPC **361/802**; 361/796; 361/798; 361/801; 361/803

(58) **Field of Classification Search**
USPC 361/778, 790, 796–803; 211/41.17
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,593,046	A *	1/1997	Katsuura et al.	211/41.15
5,967,814	A *	10/1999	Sikorski, Jr.	439/165
6,045,371	A *	4/2000	Kagawa et al.	439/74
6,328,169	B1 *	12/2001	Matsuda et al.	211/41.17
6,590,781	B2 *	7/2003	Kollipara et al.	361/760
7,009,848	B2 *	3/2006	Ruckerbauer et al.	361/785
7,180,755	B1 *	2/2007	Reznikov	361/797
7,280,373	B2 *	10/2007	Aizawa	361/803
7,891,937	B2 *	2/2011	Mohamed	414/810

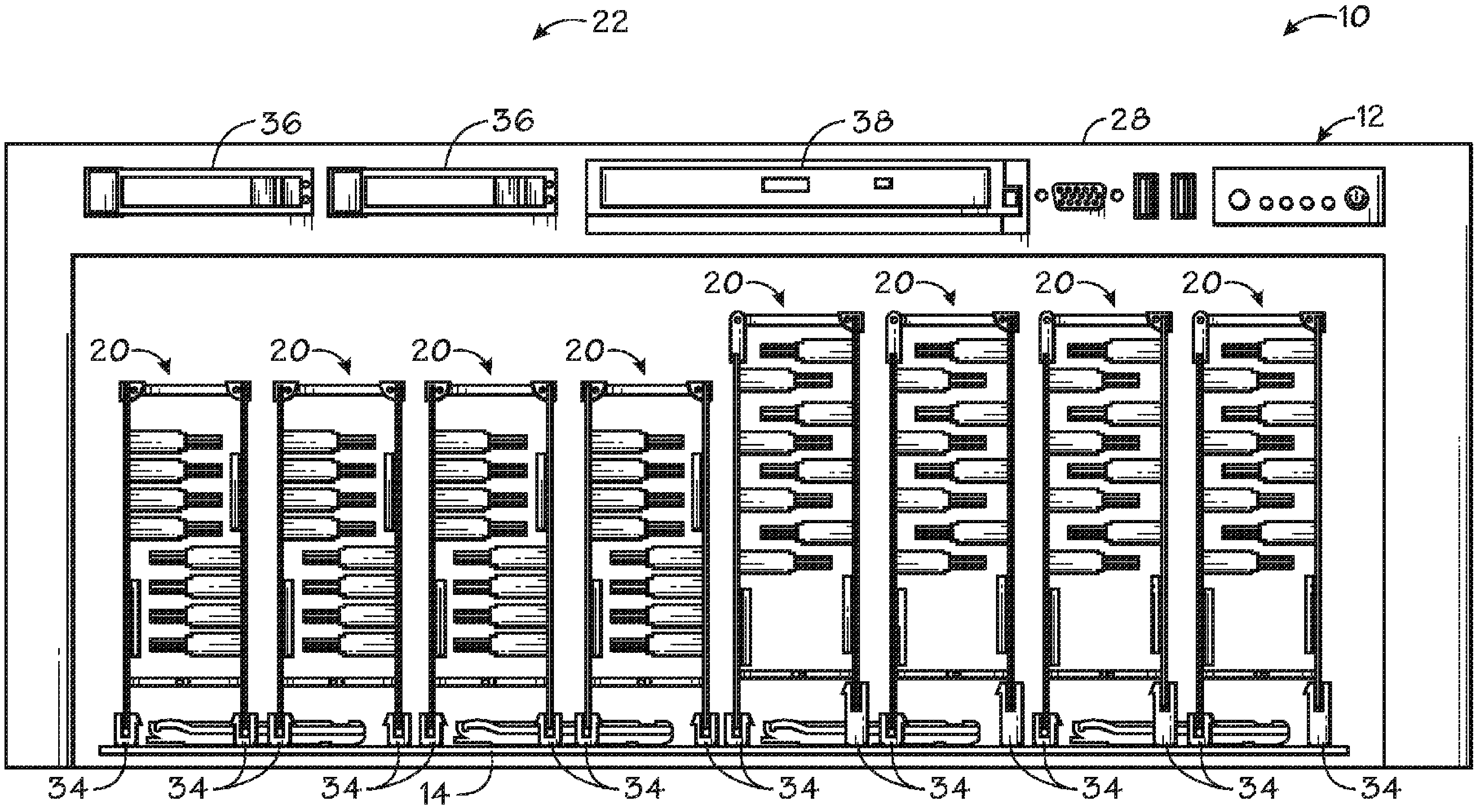
* cited by examiner

Primary Examiner — Tuan T Dinh

(57) **ABSTRACT**

A system in some embodiments includes a system having a memory module having a first board comprising a first plurality of memory receptacles configured to support a first plurality of in-line memory modules in an overlapping relationship with a second plurality of in-line memory modules disposed on a second board. Further, a system in some embodiments includes rotating first and second memory boards into a parallel configuration via a hinge coupling the first and second memory boards, and inserting the first and second memory boards into first and second board connectors simultaneously.

22 Claims, 13 Drawing Sheets



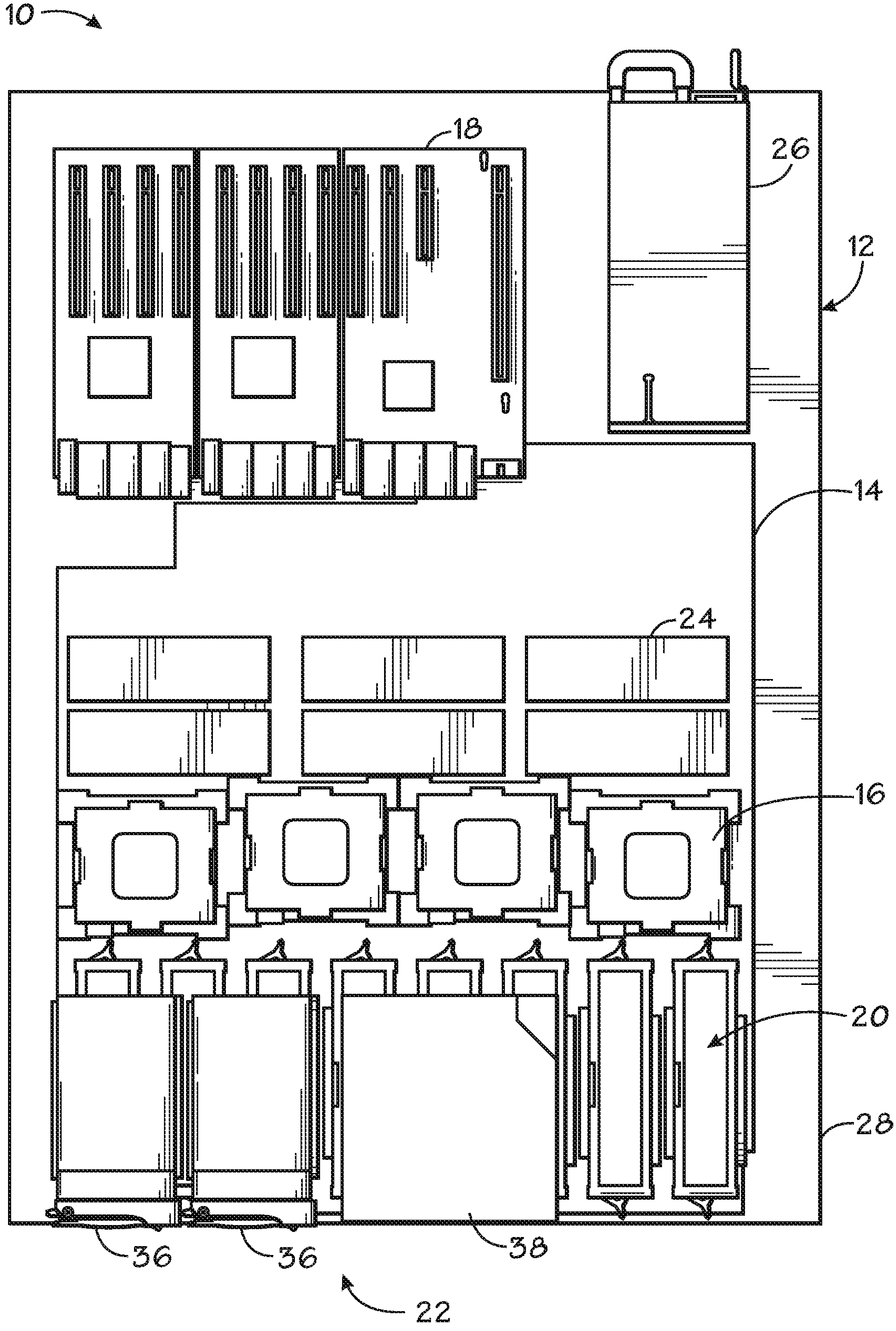


FIG. 1

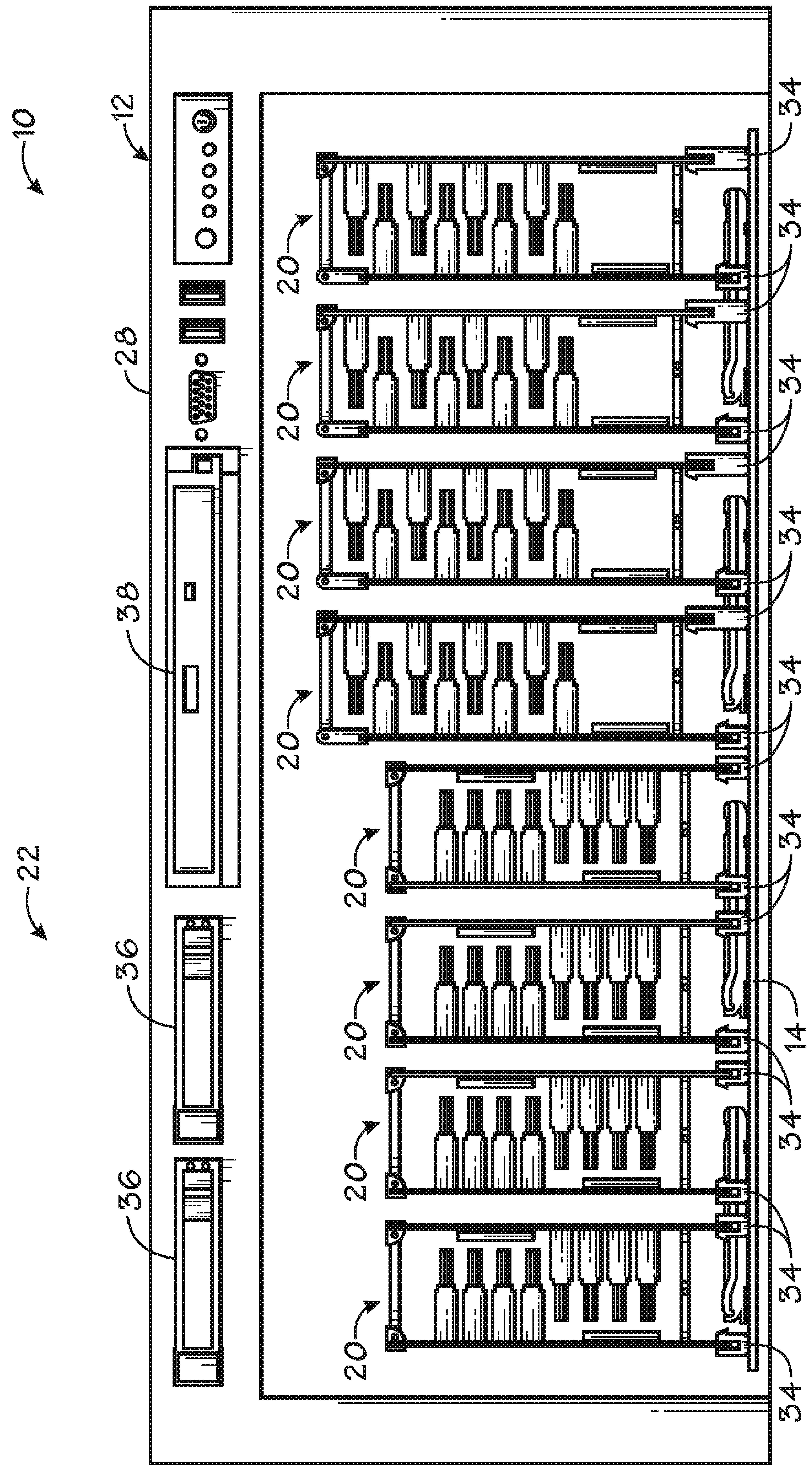

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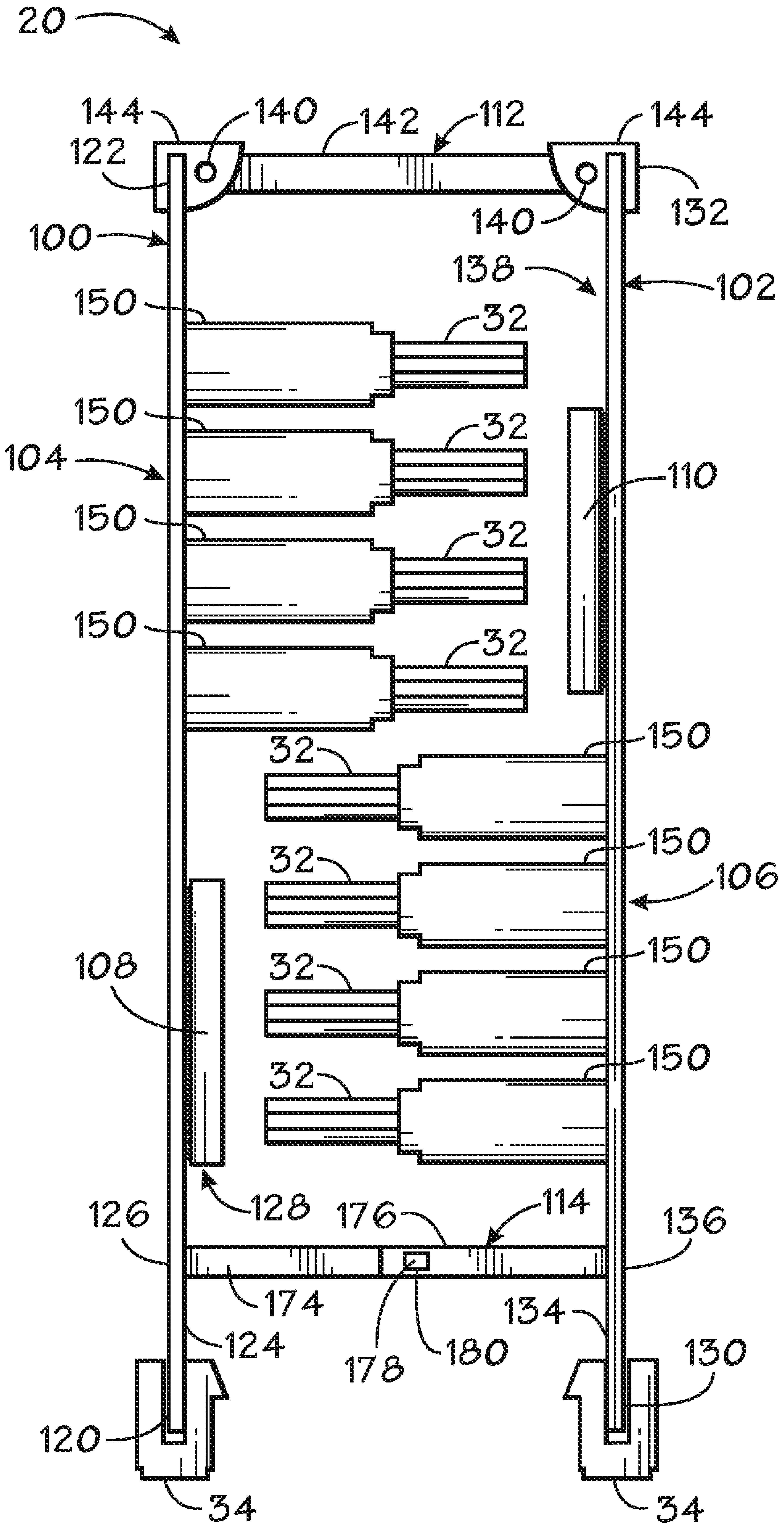
FIG. 2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32
150
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150
106
108
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114
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FIG. 3

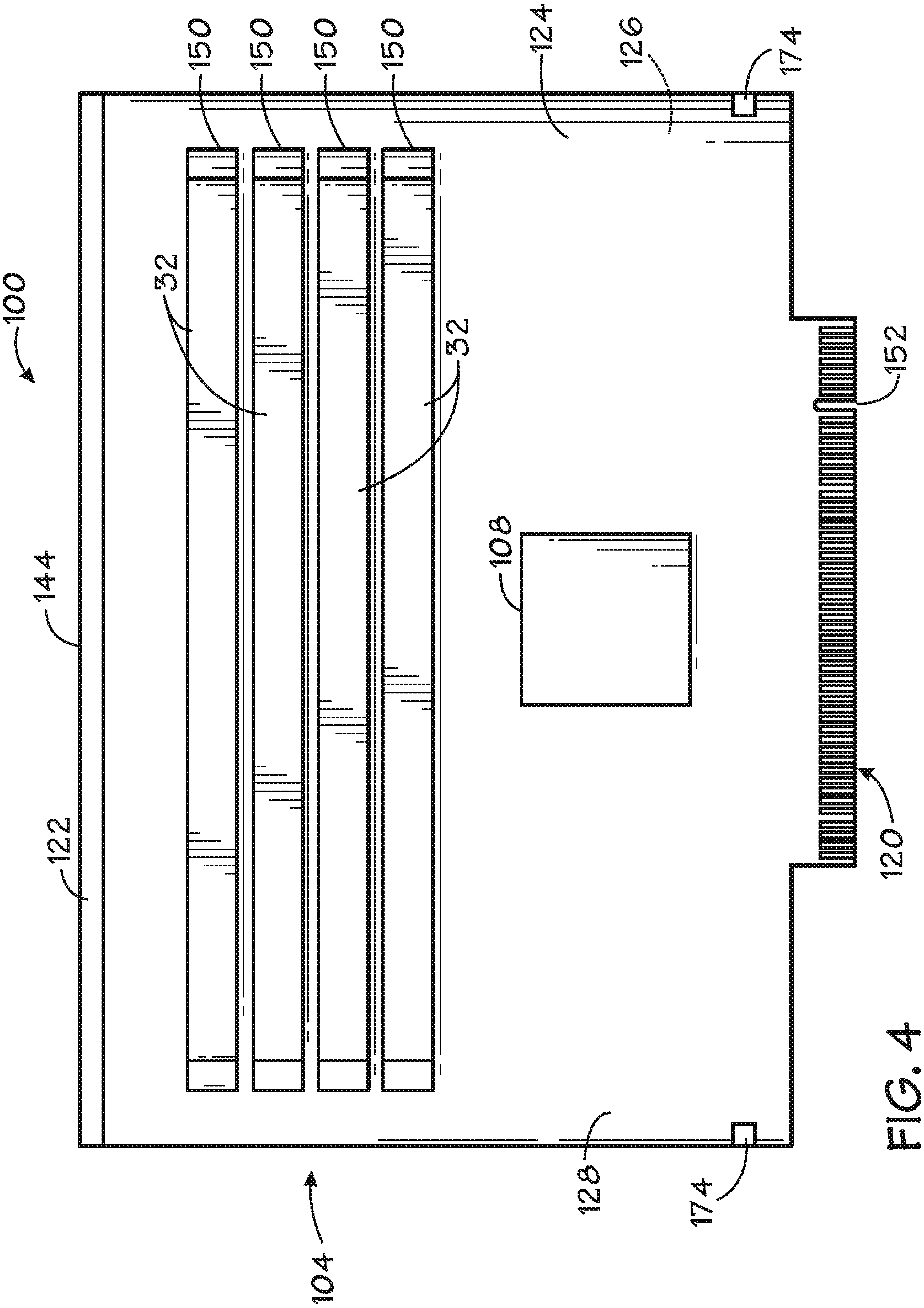
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FIG. 4

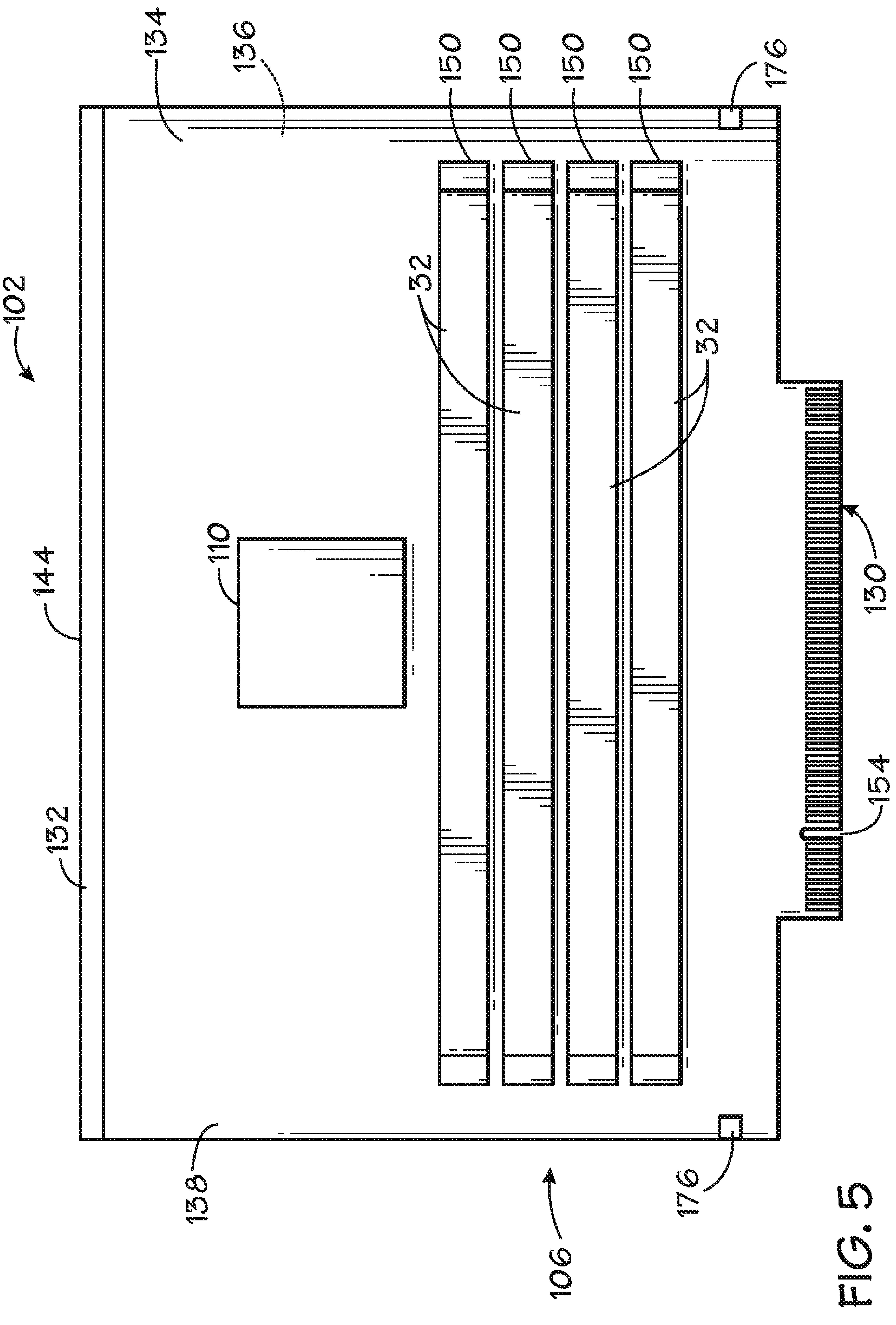
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FIG. 5

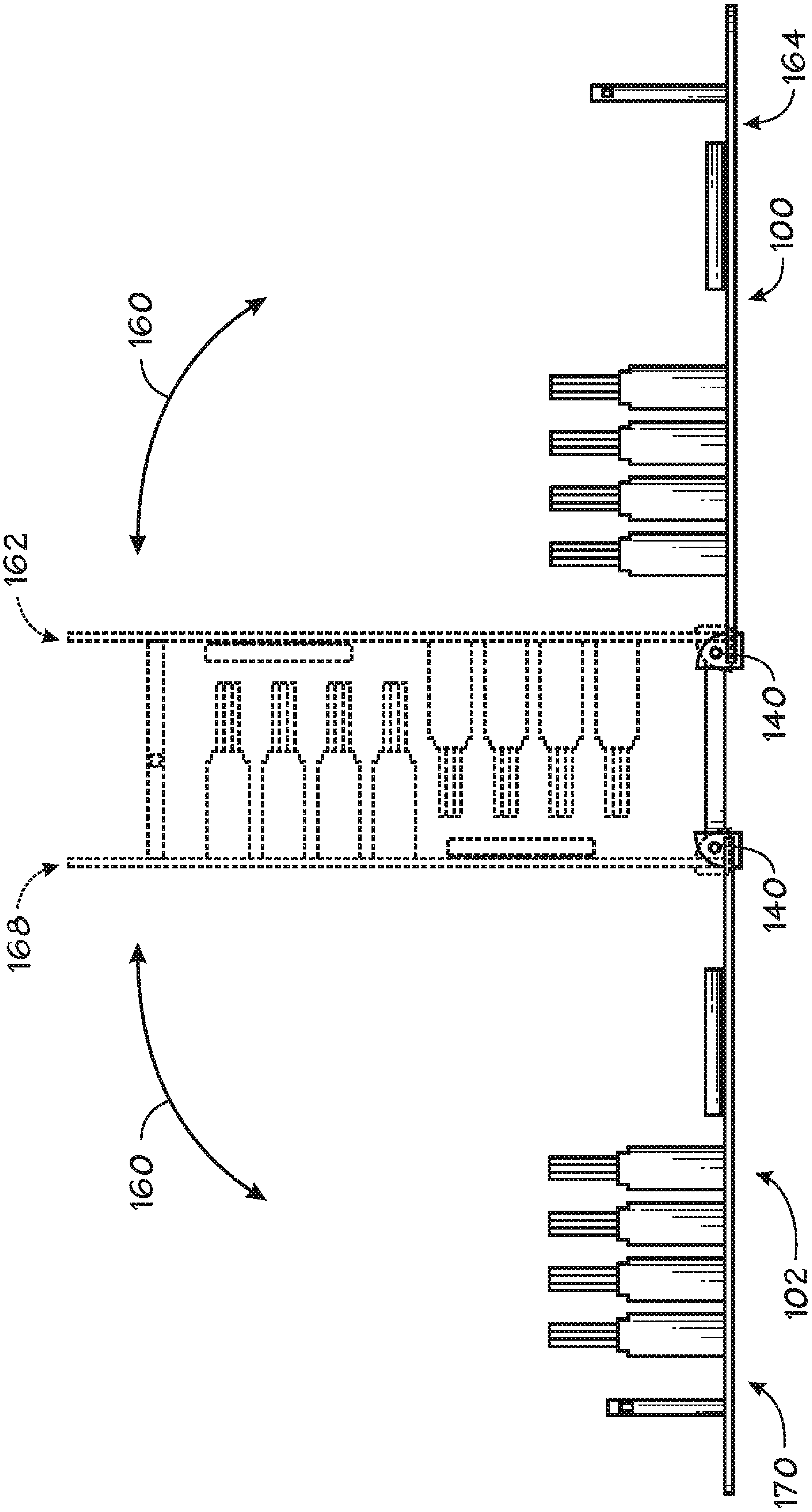

FIG. 6

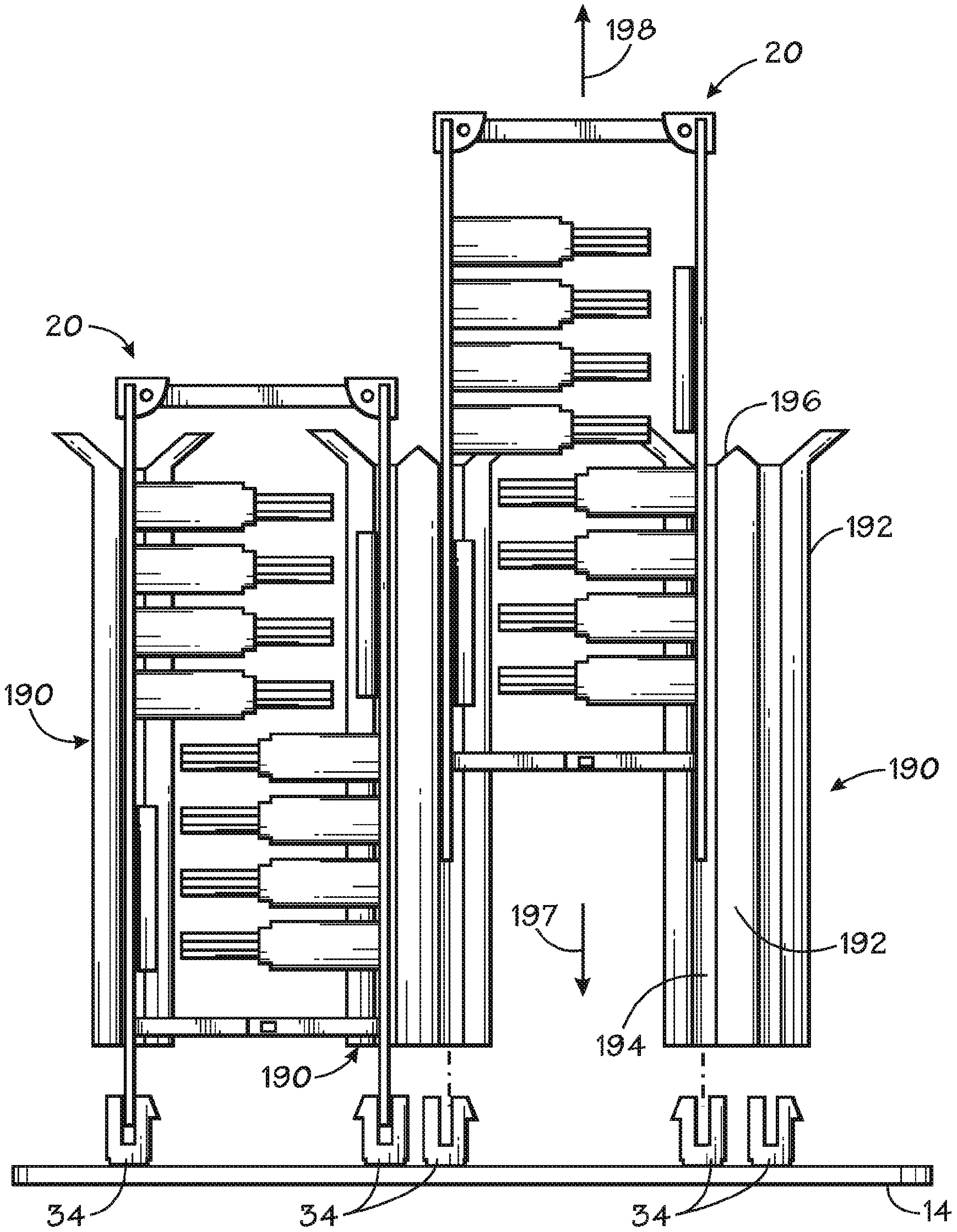

FIG. 7

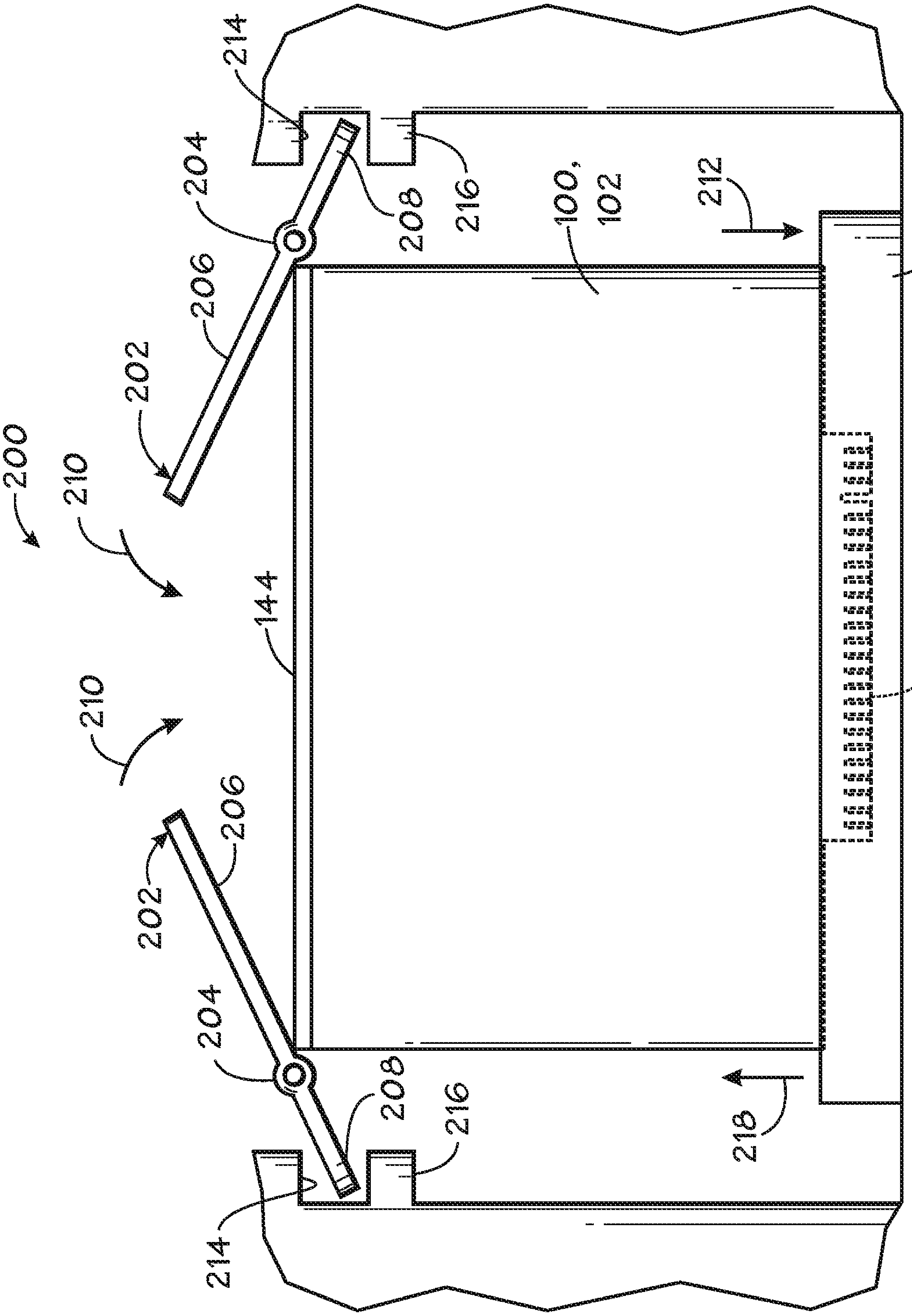
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FIG. 8

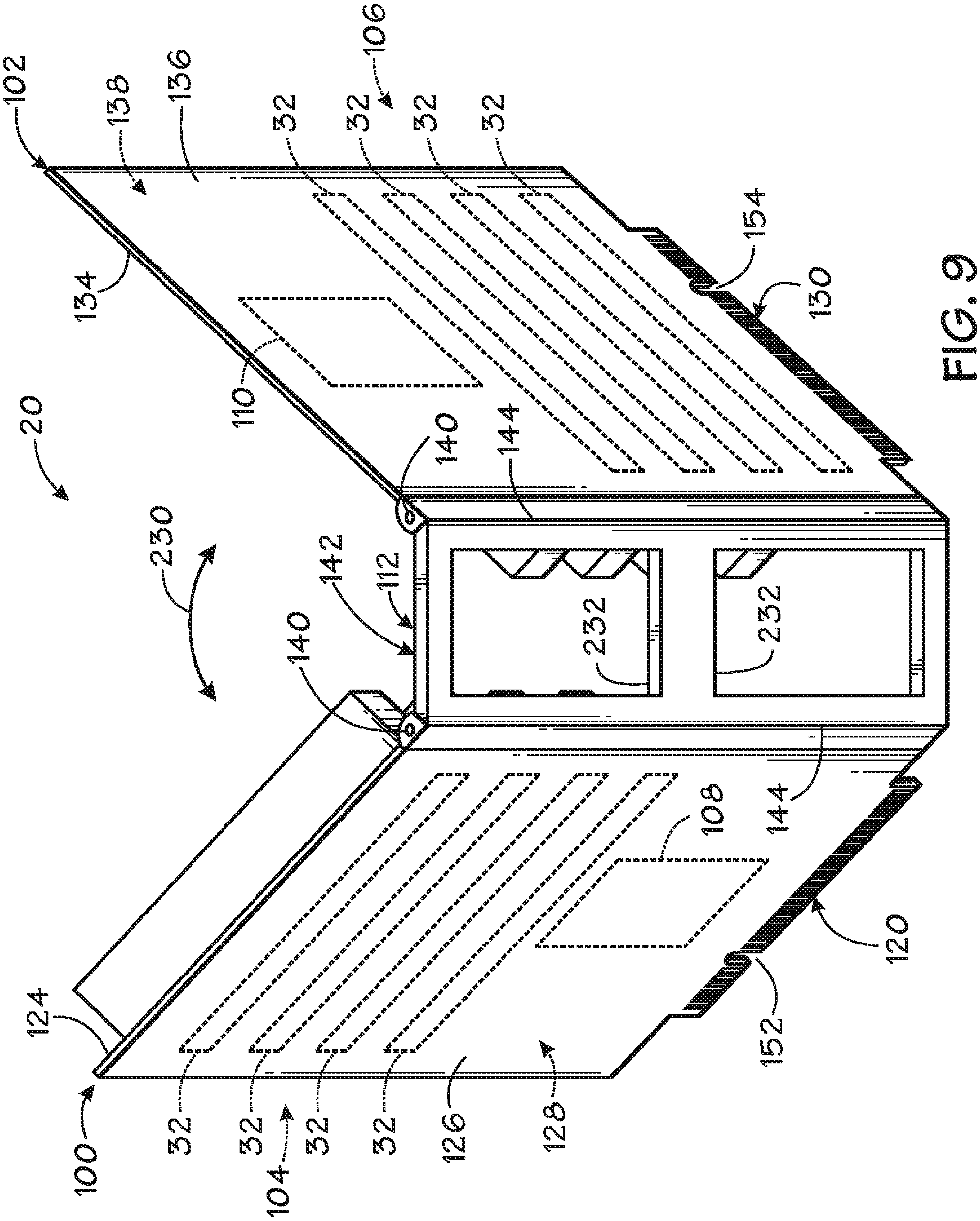
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FIG. 9

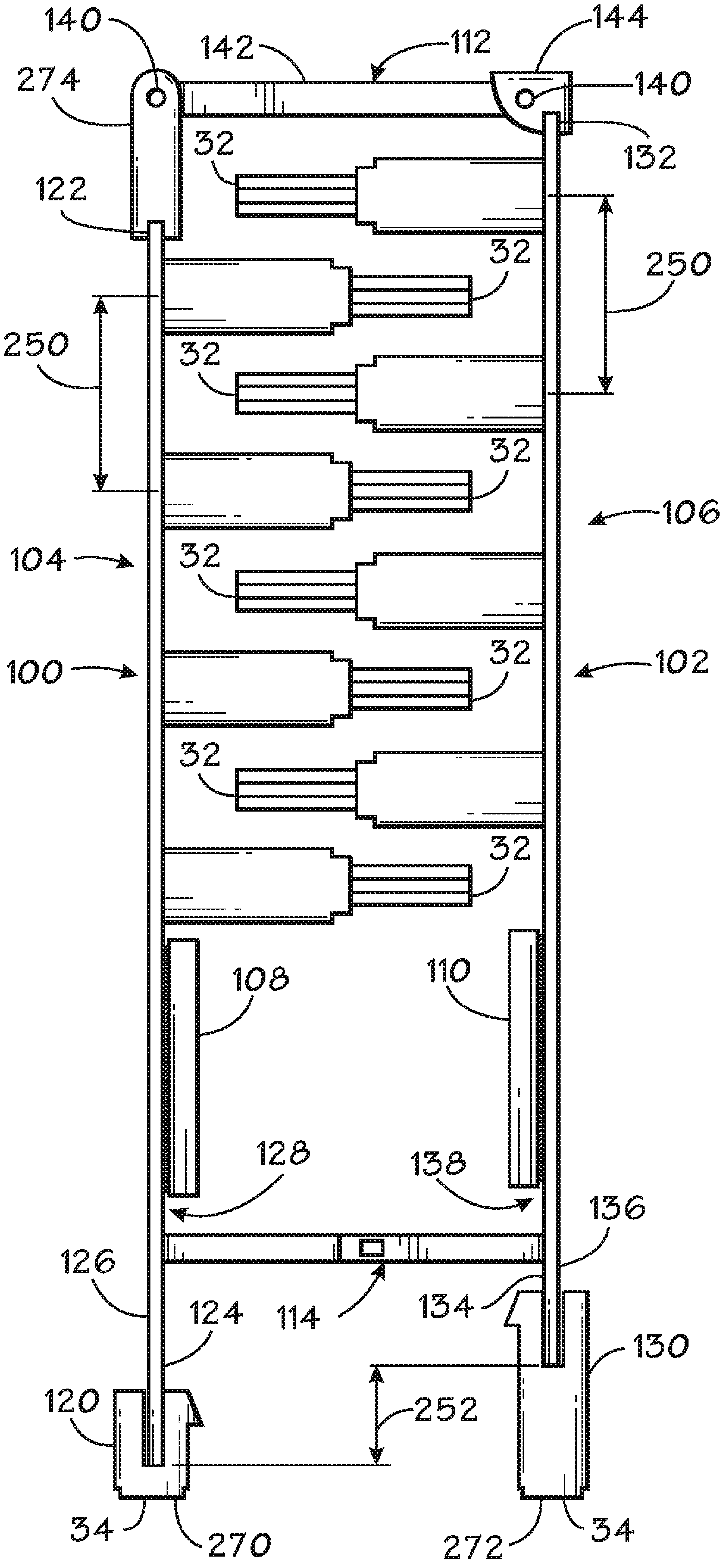
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FIG. 10

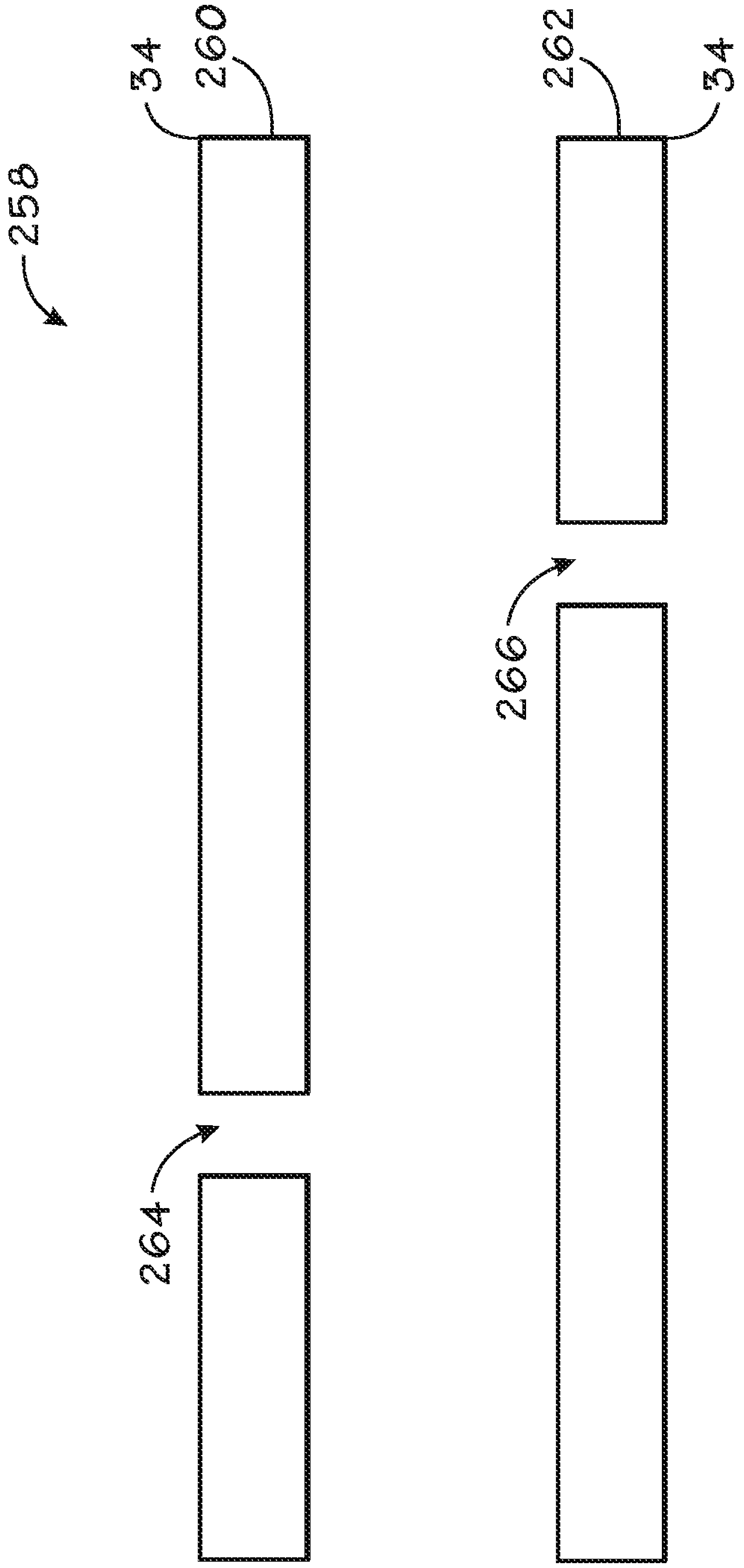

FIG. 11

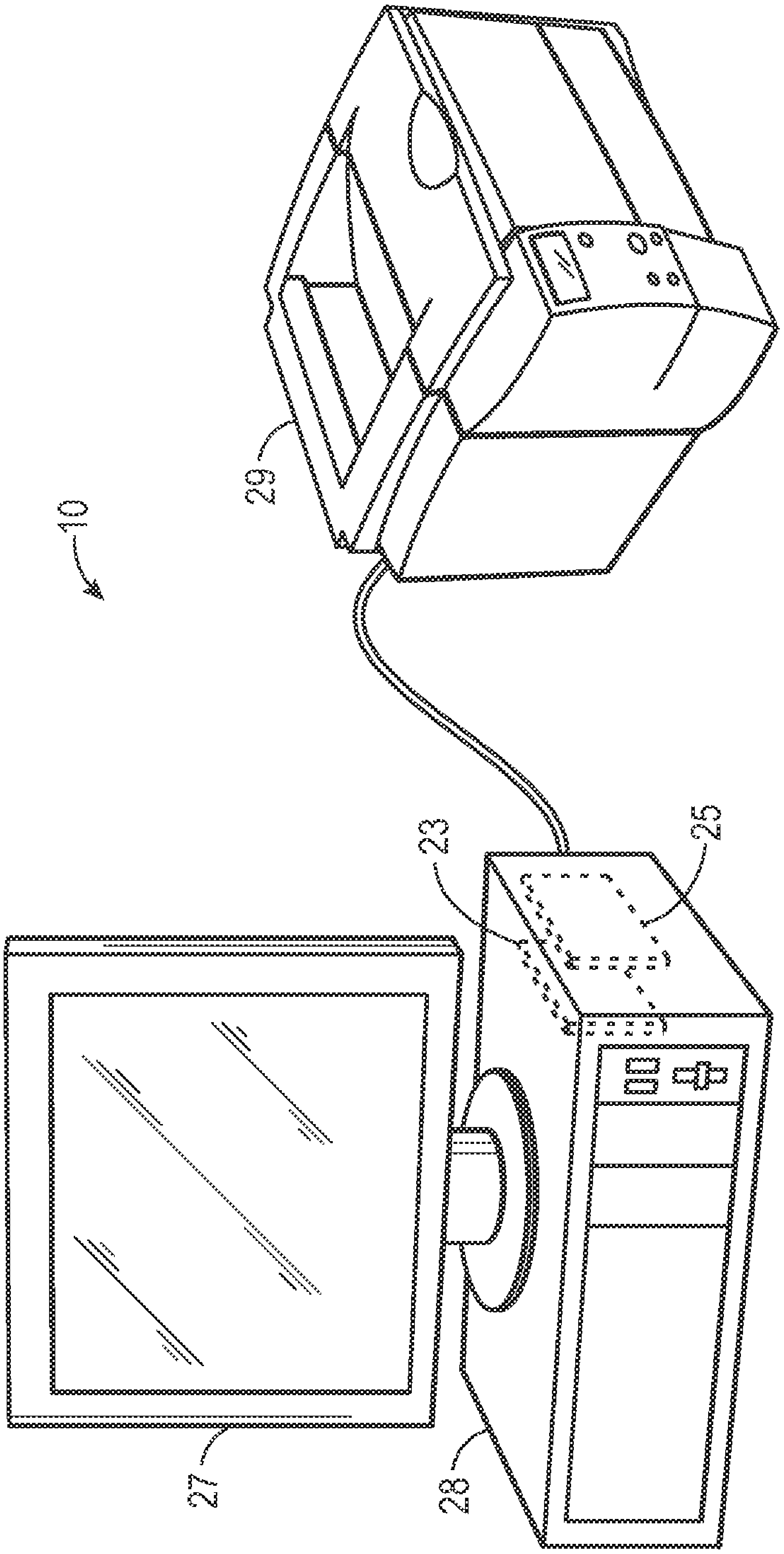

FIG. 12

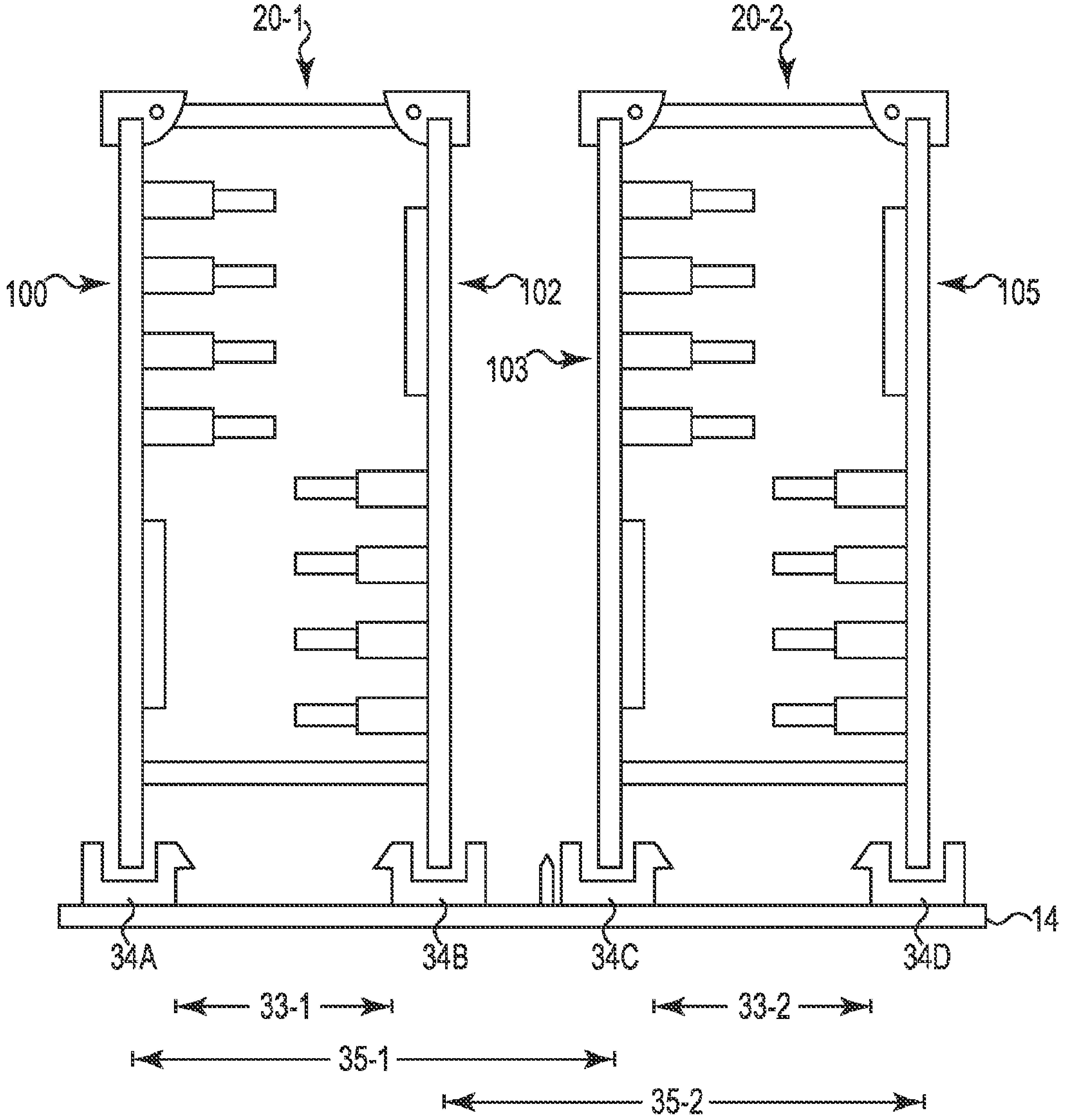

Fig. 13

MEMORY SYSTEM

BACKGROUND

This section is intended to introduce the reader to various aspects of art, which may be related to various aspects of the present invention that are described or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present invention. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

Computer systems are generally employed in numerous configurations to provide a variety of computing functions. For example, computer systems may include personal computer systems (e.g., desktop and laptop computers), as well as, commercial systems (e.g., servers or industrial computers). Each of these systems may rely on a plurality of components interacting to provide reliable computing power and bandwidth. For instance, computer systems may employ a combination of processors, memory, input/output devices, disk drives, power supplies, fans, and the like to operate effectively. As the demand for computing power increases, these systems may be expanded to provide computing for a growing number of applications. Generally, expanding the systems may include the addition of more components (e.g., processors and memory) to provide additional computing power.

Although expanding the system with additional components may be feasible in some systems, it may not be desirable in others. For example, in server applications, the system may be limited by space constraints that reduce the ability to expand the physical size of the system. For example, a chassis that encloses the system may be designed to fit within a standard server rack with a given width (e.g., 19-28 inches) and depth (e.g., 24-42 inches). Accordingly, any additional components to the system may be designed into the available space and volume. Similarly, other products, such as consumer desktops, may be limited in size by consumer demand. For instance, users may desire a powerful computer system housed in a compact form factor. Thus, it may be desirable for a computer system to house an increasing number of components in a limited volume or space. Further, it may be desirable that the components remain accessible to enable a user or service technician to access components (e.g., memory) without exposing them to a high potential of damaging the components. Accordingly, it may desirable that computer systems include a compact form factor that enables access to the components.

BRIEF DESCRIPTION OF THE DRAWINGS

Advantages of one or more disclosed embodiments may become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIG. **1** is a top view of an embodiment of a computer system having memory modules arranged in a unique foldable memory book;

FIG. **2** is a side view of an embodiment of the computer system of FIG. **1**;

FIG. **3** is an end view of an embodiment of the memory module of FIGS. **1** and **2**;

FIG. **4** is a side view of a first board of FIG. **3**;

FIG. **5** is a side view of a second board of FIG. **3**;

FIG. **6** is an end view of an embodiment of the memory module of FIG. **3** in opened and closed positions;

FIG. **7** is an end view of an embodiment of a plurality of the memory module of FIG. **3** disposed in a guide;

FIG. **8** is a side view of an embodiment of the memory module of FIG. **3** including a latching mechanism;

FIG. **9** is a perspective view of an embodiment of the memory module of FIGS. **1** and **2** including a vertical hinge;

FIG. **10** is an end view of another embodiment of the memory module of FIGS. **1** and **2**; and

FIG. **11** is a block diagram of a connector layout of the memory modules of FIG. **10**.

FIG. **12** is a front view of an embodiment of the computer system of FIG. **1**.

FIG. **13** is an end view of an embodiment of two memory modules of FIGS. **2** and **3**.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

One or more exemplary embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, not all features of an actual implementation are described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

FIGS. **1** and **2** illustrate top and side views of an embodiment of a computer system **10** having a foldable memory module (e.g., book) configured to support a plurality of in-line memory modules. As discussed in further detail below, the foldable memory module may include first and second boards that each support a plurality of in-line memory modules. For example, in certain embodiments, each of the boards is configured to support four in-line memory modules. Further, embodiments of the foldable memory modules may include coupling the first and second boards together via a hinge mechanism. For example, in certain embodiments, the hinge mechanism may enable the boards to fold proximate to one another (e.g., parallel with space for the memory in between) to enable installation of the boards into adjacent memory slots/connectors in the computer system. Further, in certain embodiments, the hinge may enable a user to unfold the memory module for access to each of the in-line memory modules. In other words, the foldable memory module may be folded closed for installation into a computer system, and unfolded to access each in-line memory module when the foldable memory module is removed from the computer system.

Embodiments may also include positioning in-line memory module connectors on the first and second boards such that when the memory module is folded (e.g., closed) the in-line memory modules of the first board overlap with the in-line memory modules of the second board. In other words, the portions of the in-line memory modules are disposed proximate to one another to provide a space savings as compared to not overlapping the in-line memory modules. For example, in certain embodiments, the in-line memory modules of the first board may be disposed near a top portion of the first board and the in-line memory modules of the second board disposed near a bottom portion of the second board. Thus, folding the memory module closed enables the in-line memory modules to overlap without mechanical interference (e.g., hitting one another). In other embodiments, the first board and second board may include a layout that staggers each of the in-line memory modules with a given offset. Accordingly, folding the memory module closed may enable each of the in-line memory modules of the first board to fit between or proximate to each of the in-line memory modules of the second board, such that there is an alternating overlap between the first board in-line memory modules and the second board in-line memory modules. In other words, there may be a gap between the in-line modules on each board such that the in-line memory modules may fit between one another when the boards are folded closed. Further, embodiments may include features, such as varying connector heights, latching mechanisms, clasps, guides, and the like.

An exemplary computer system **10** is illustrated in FIGS. **1**, **2**, and **12** in accordance with one embodiment of the present technique. In the illustrated embodiment, the computer system **10** includes a server **12** having various components, including a motherboard **14**, processors **16**, input/output (I/O) devices **18**, memory modules **20**, drives **22**, an audio card **23**, fans **24**, a video card **25**, and a power supply **26**, all within a chassis **28**. The drives **22** may include hard drives, optical drives, disk drives, or a combination thereof. The computer system **10** also may include a variety of peripheral devices, such as a keyboard, mouse, monitor **27**, printer **29**, camera, scanner, or a combination thereof.

The motherboard **14** may include a printed circuit board (PCB) or other hardware that enables connection and communication between the various components of the system **10**. For example the motherboard **12** may include a printed circuit board (PCB) having a plurality of layers, electrical traces, connectors, integrated circuits (IC's), and the like to enable mounting of the components, and transmission of signals and power. In the illustrated embodiment, the processors **16**, the I/O devices **18**, the memory modules **20**, and the fans **24** may be directly coupled to the motherboard **14**. In other embodiments, additional components, including the drives **22** may be directly coupled or indirectly coupled (e.g., via a cable) to the motherboard **14**.

The central processing unit **16** may include one or more processors that carry out various computing tasks of the system **10**. For example, a processor **16** may include a processor manufactured by Intel Corporation of Santa Clara, Calif., or Advanced Micro Devices (AMD) Sunnyvale, Calif. In the illustrated embodiment, the system **10** includes a multi-processor configuration having four processors **16**. In other embodiments, the system **10** may include a single processor **16** or any number of processors **16**.

The input/output devices **18** may include connections to various external devices of the system **10**. For example, the input/output devices **18** may include PCI (peripheral component interconnect) Express or PCI bus expander cards plugged into the motherboard via I/O connectors. Further, the I/O devices **18** may include peripherals, keyboards, USB (Universal Serial Bus) ports, serial ports, and the like.

The memory modules **20** may include a variety of memory devices and configurations. In certain embodiments, the memory modules **20** may include SIMMs (single in-line memory modules) or DIMMs (dual in-line memory modules) **32**. For example, in the illustrated embodiment, the system **10** includes eight memory modules **20** that each includes eight in-line memory modules **32**. Further, each of the memory modules **20** is coupled to the system **10** and the motherboard **14** via board sockets **34**. Thus, the system **10** includes a total of sixty-four in-line memory modules **32** coupled to the motherboard **14** via sixteen board sockets **34**.

The drives **22** may include hard drives, media drives, and the like. For example, in the illustrated embodiment, the drives **22** include two 2.5 inch SFF (small form factor) SAS (serial attached SCSI (small computer system interface)) hard drives **36** and a DVD-R/W (digital video disk-read/write) drive **38**. Other embodiments may include 5.25 inch drives, external drives, or the like.

The fans **24** may provide for cooling of the system **10**. For example, the fans **24** may circulate air through the chassis **28**, and circulate air over the components to remove heat that is produced by the system **10** and its components. The illustrated embodiment includes six fans **24** internal to the system **10** that are configured to provide air flow through the chassis **28**, and airflow across the processors **16**, the I/O devices **18**, the memory modules **20**, the in-line memory modules **32**, and the drives **22**. Other embodiments may include alternate fan **24** configurations. For example, embodiments may include any number of fans **24** located internal and/or external to the chassis **28**.

One or more power supplies **26** may provide power to the system **10**. For example, in the illustrated embodiment, the power supply **26** may receive power via an alternating current (AC) or a direct current (DC) source, and transmit the power to each of the components via the motherboard **14**, or other cabling internal to system **10**. In other embodiments, the system **10** may include alternate power configurations and schemes. For example, other embodiments may include an external power supply **26** that delivers power to the system **10** via a common backplane or cabling.

As mentioned previously, the chassis **28** may provide an enclosure for each component of the system **10**. For example, in the illustrated embodiment, the system **10** includes a 4U rack mount server chassis **28** configured to be mounted in modular rack mount server system. Similarly, the chassis **28** may include other form factors, such as a 4U rack mount server. Further, other embodiments may include a chassis **28** or enclosure generally associated with desktop computer systems, portable computer systems, industrial computer systems, and the like.

As mentioned previously, the system **10** may include multiple processors **16** and multiple memory modules **20**. As will be appreciated, each of the processors **16** may rely on one or more of the memory modules **20** to store and access data that may be associated with processing functions. Further, in certain embodiments and configurations, each processor **16** may be capable of simultaneously supporting a plurality of memory modules **20** and in-line memory modules **32**. For example, in the illustrated embodiment, each processor **16** is capable of supporting up to four memory channels connected to a remote memory buffer. Further, each remote memory buffer includes an interface to a standard DRAM (dynamic random access memory) interface that is capable of supporting four DIMM modules **32**. In other words, each processor **16** is capable of supporting up to 16 DIMM modules **32**. Thus, the four processors **16** of the system **10** are capable of supporting up to 64 DIMM modules **32**. Accordingly, systems **10** that include an increased number of processors **16** may be capable of supporting a large number of in-line memory modules **32**.

Although adding multiple processors **16** may enable the system **10** to support a plurality of in-line memory modules **32** (e.g., DIMMs), other constraints of the system **10** may limit the actual number of in-line memory modules **32** that the system **10** can support. For example, in the system **10** (e.g., a server system), the physical dimensions of the chassis **28** may limit the space available for each the components of the system **10**. In other words, the standard size of the chassis **28** may limit expansion of the chassis **28** to provide enough space/volume to support an increased number of the in-line memory modules **32**. Generally, each portion (e.g., zone) of the system **10** may consume its own volume and does not share or encroach in another zone of the system **10**. For example, in the illustrated embodiment, there are four zones, including: the memory, the CPU, the fan, and the I/O zones. Accordingly, the zone remaining for the memory may include a function of the total system **10** volume minus the volume associated with the CPU, the fan, and the I/O zones. Thus, in the standard 4U chassis **28**, subtracting the length of the I/O devices **18**, the width of the fans **22**, and the volume of the processors **16**, and associated heat sinks, may drastically reduce the volume available for the in-line memory modules **32**.

In a compact computer system **10**, such as a server, the width and depth of the chassis **28** may be fixed relative to the width and depth of a standard server rack. Further, the overall height of the system **10** and the chassis **28** may be driven by physical constraints, as well as, desires of the consumer and industry trends. Accordingly, it may be desirable that a plurality of the in-line memory modules **32** be disposed in a limited volume. However, providing a plurality of in-line memory modules **32** in a limited volume may provide for additional challenges. Provided below is a system and method that addresses volumetric and other constraints associated with assembling a plurality of in-line memory modules **32** into a single chassis **28**.

In an exemplary embodiment, a plurality of memory modules is disposed in the chassis **28** in a foldable book-style configuration. For example, FIG. **2** illustrates the system **10** including sixty-four in-line memory modules **32** disposed in a plurality of memory modules **20** and FIG. **13** illustrates an embodiment of two memory modules **20**-**1**, **20**-**2** of FIGS. **2** and **3**. In the embodiments, each of the memory modules **20**, **20**-**1**, **20**-**2** includes foldable configuration that supports a plurality of in-line memory modules **32**. For example, in the illustrated embodiments, each of the memory modules **20**, **20**-**1**, **20**-**2** includes eight in-line memory modules **32** that are coupled to the system **10** via tow board connectors **34**, **34**-A, **34**-B, **34**-C, **34**-D disposed on the motherboard **14**. The embodiments of the memory modules **20**, **20**-**1**, **20**-**2**, each provide a compact form factor by overlapping the in-line memory modules **32** such that an increased number of in-line memory modules **32** is substantial higher than a normal mounting of memory modules, because the modules **32** are in closer proximity, overlapping, and so forth.

FIG. **3** illustrates an exemplary embodiment of the memory module **20** and FIG. **13** illustrates an exemplary embodiment of two of the memory modules **20**-**1**, **20**-**1**. In the illustrated embodiments, the memory module **20**, **20**-**1**, **20**-**2** includes a first memory board **100** (e.g. a third memory board **103**), a second memory board **102** (e.g., a fourth memory board **105**), a first set of in-line memory modules **104**, a second set of in-line memory modules **106**, a first memory controller **108**, a second memory controller **110**, a hinge **112**, and a clasp **114**. The first memory board includes a first board connection pins **120**, a first hinge support edge **122**, a primary face **124**, a secondary face **126**, and a component region **128**. The second memory board **102** includes second board connection pins **130**, a second hinge support **142**, and hinge ends **144**. The first set of memory modules **104** and the second set of memory modules **106** each include four in-line memory modules **32**; thus the memory modules **20**, **20**-**1**, **20**-**2** includes a total of eight in-line memory modules **32**. Further, the illustrated embodiments includes include board connectors **34**, **34**-A, **34**-B, **34**-C, **34**-D coupled to the memory module **20**, **20**-**1**, **20**-**2**. Illustrated in the embodiments of FIGS. **2** and **13** the board connector **34**, **34**-A **34**-B **34**-C **34**-D can be separated by a first distance **33**-**1** and a second distance **35**-**1** from another on the circuit board **14**.

The boards **100** and **102** may provide for mounting multiple in-line memory modules **32** to a single board connector **34**. For example, in the illustrated embodiment, the boards **100** and **102** each include four in-line memory sockets **150** that enable coupling four in-line memory modules **32** to the board **100**. FIGS. **4** and **5** illustrate a side view of each of the first board **100** and the second board **102**. In one embodiment, the sockets **150** may include a 144 pin DIMM connector, a 168 pin DIMM connector, a 184 pin DIM connector, a 200 pin DIMM connector, a 240 pin DIMM connector, or other types of edge connectors. Accordingly, the sockets **150** can provide for plugging-in and unplugging of multiple in-line memory modules **32** to the boards **100** and **102**. Other embodiments may include any number of sockets **150**. For example, embodiments of the boards **100** and **102** include one, two, three, four, five, six, or more sockets **150** each configured to accept an in-line memory module **32**.

Further, the boards **100** and **102** each include the component regions **128** and **138**. In one embodiment, each of the component regions **128** and **138** may include a surface area or keep-out region of the board that does not include sockets **150**, connectors, or other components configured to couple in-line memory modules **32** to the board **100**. Further, the component regions **128** and **138** may be reserved for the placement of lower profile components (e.g., IC's) that do not extend a substantial distance from the primary faces **124** and **134** of the boards **100** and **102**. For example, in the illustrated embodiment, the first memory controller **108** and the second memory controller **110** are each coupled to the boards **100** and **102** in the component regions **128** and **138**, respectively. In one embodiment, the memory controller **108** and **110** may include a generic memory interface device (e.g., a buffer). This may enable a bus-to-bus conversion step (e.g., DDR-3 to a high-speed memory controller to memory expander/buffer link). Further, in other embodiments, the component regions **128** and **138** may not include components, active components, and/or any components or structures that can other wise interfere with other devices and components (e.g., in-line memory modules **32**) disposed proximate to the component regions **128** and **138**. In other words, the component regions **128** and **138** include low profile or no components to enable in-line memory modules **32** to be disposed in the area near the component regions **128** and **138**.

The boards **100** and **102** each include a connector that enables the boards to communicate with other components of the system **10**. For example, each board **100** and **102** includes a set of conductive fingers that are mated with complementary conductive members internal to the board connectors **34**. In other words, the boards **100** and **102** may include standard memory pins that may be plugged into standard memory sockets. Another embodiment may include a non-standard-memory socket and/or any suitable connector **34** to connect memory boards **100** and **102** to the motherboard **14**. In the illustrated embodiment, the first board **100** includes the first board connection pins **120** and the second board **102** includes the second board connection pins **130**. The connection pins **120** and **130** can be coupled to the board connectors **34**. For example, the board connection pins **120** and **130** may include configurations for connection to a 144 pin DIMM connector, a 168 pin DIMM connector, a 184 pin DIM connector, a 200 pin DIMM connector, a 240 pin DIMM connector, or the like. The board connection pins **120** and **130** also include features that ensure correct placement of the boards **100** and **102** into the board connectors **34**. For example, in the illustrated embodiment, the first board **100** includes a first notch **152**, and the second board **102** includes a second notch **154**. The notches **152** and **154** correspond to a complementary protrusion on the board connectors **34**. For example, the notches **152** and **154** correspond to a keying feature of the corresponding mating connector **34**. Other embodiments may include a plurality of notches, or notches in different locations (e.g., notches that correspond to a particular type of memory).

In one embodiment, the first and second boards **100** and **102** of the memory module **20** are mechanically coupled to one another. Mechanically coupling multiple boards may provide for alignment of the boards **100** and **102** relative to one another, as well as, enable removal of multiple boards (e.g., boards **100** and **102**) simultaneously. In one embodiment, the boards **100** and **102** are coupled via the hinge **112**. For example, in the illustrated embodiment, the hinge **112** includes the hinge support **142** spanning the distance between the two hinge ends **144**. The hinge ends **144** are coupled to the first hinge support edge **122** of the first board **100**, and the second hinge support edge **132** of the second board **102**. Further, the hinge **112** includes hinge pins **140** that couple the hinge support **142** to the hinge ends **144**. Accordingly, the hinge **112** enables the boards **100** and **102** to rotate relative to one another about the axes of the hinge pins **140**.

FIG. **6** illustrates an embodiment of the memory module **20** of FIG. **2** that is rotated between a closed position **162**, **168** (dashed lines) and an open position **164**, **170** (solid lines). In the illustrated embodiment, the first board **100** rotates about the hinge pin **140** in the direction of arrow **160** between the closed position **162** and the open position **164**. Similarly, the second board **102** rotates about the hinge pin **140** in the direction of arrow **166** between the closed position **168** and the open position **170**.

In an embodiment that includes both boards **100** and **102** in a closed (e.g., folded or closed book) position, the memory module **20** may be configured for installation into the connectors **34** of the computer system **10**. For example, when the first board **100** is in the closed position **162** and the second board **102** is in the closed position **168**, the memory module **20** can be plugged into the board connectors **34**, as illustrated in FIGS. **2** and **3**. In the closed position, the boards **100** and **102** are disposed parallel and offset from one another. The offset is provided via the length of the hinge **112**, for instance.

The layout of the boards **100** and **102** enables the boards **100** and **102** to be closed with minimal interference between the components (e.g., the in-line memory modules **32**) of the memory module **20**. For example, in the illustrated embodiment, the first set of in-line memory modules **104** are disposed near a top portion of the first board **100**, and the component region **128** is located in a lower portion of the first board **100** adjacent to the first set of memory modules **104**. Similarly, the second board **102** includes the second set of in-line memory modules **106** disposed near a lower portion of the second board **102**, and the component region **138** is located in an upper portion of the second board **102** adjacent to the second set of memory modules **106**. Accordingly, the complementary layout of the boards **100** and **102** enables positioning (e.g., closing) the boards **100** and **102** without interference between the components (e.g., in-line memory modules **32**). For example, when the memory module **20** is closed, the first set of in-line memory modules **104** is disposed proximate the component region **138** of the second board **102**, and the second set of in-line memory modules **106** is disposed proximate to the component region **128** of the first board **100**. Thus, the first set of in-line memory modules **104** and the second set of in-line memory modules **106** overlap in the separate regions **128** and **138** between the generally parallel closed boards **100** and **102**. The overlap between the modules may reduce the distance between the boards **100** and **102**. It is noted that the overlap may create interference between the in-line memory modules **32** if the second board **102** was separately removed from the board connectors **34** of the system **10** with the first board **100** installed. However, coupling the boards **100** and **102** via the hinge **112** enables the boards **100** and **102** to be removed simultaneously to reduce or eliminate the potential for interference.

Further, in an open (e.g., unfolded or open book) position the memory module **20** may enable increased access to the primary faces **124** and **134** of the boards **100** and **102**, and increased access to the in-line memory modules **32**. For example, in the embodiment illustrated in FIG. **6**, when the first board **100** is in the open position **164**, and the second board **102** is in the open position **170**, the boards **100** and **102** are disposed parallel and in the same plane, such that each of the in-line memory modules **32** are accessible. In other words, the memory module **20** is unfolded such that a user may plug-in or un-plug the in-line memory modules **32** with reduced interference.

The memory module **20** may also include a device that blocks or reduces the likelihood of the boards **100** and **102** opening inadvertently. For example, in the illustrated embodiment, the memory module **20** includes the clasp **114**. The clasp **114** enables coupling of the boards **100** and **102** such that the boards **100** and **102** do not rotate independently, and, thus may block the memory module **20** from opening inadvertently. For example the clasp **114** includes a first clasp member **174** coupled to the first board **100**, and a second clasp member **176** coupled to the second board **102**. The clasp members **174** and **176** are mechanically coupled to fix the boards **100** and **102** relative to one another. For example, in the illustrated embodiment, the first member **174** includes a bump **178** that is received by a complementary recess **180** of the second member **176**.

In other embodiments, the clasp **114** may simply provide for spacing between the boards **100** and **102**. Enabling the boards **100** and **102** to maintain a minimum distance may prevent the boards **100** and **102** from rotating into one another, which could otherwise result in interference between the in-line modules **32** and/or other components of the memory module **20**. For example, in one embodiment, the clasp **114** may include a single member coupled to the first board **100** or the second board **102**. In such an embodiment, the clasp **114** acts as a spacer (e.g., bumper) between the boards **100** and **102**. In another embodiment, the clasp **114** may include the first and second members **174** and **176** disposed between the boards such that they maintain a distance between the two boards **100** and **102**, but do not mechanically couple. Accordingly, such an embodiment may provide a two piece spacer (e.g., bumper) that does not to prevent the boards **100** and **102** from opening.

Further, the memory module **20** may also include features to regulate the amount each board **100** and **102** is rotated. For example, in one embodiment, the hinge **112** may include a stop that blocks the boards from opening, or that enables the boards to open in a particular sequence (e.g., first board **100** unfolds and, then, the second board **102** folds open). In addition, in certain embodiments, the stop blocks the boards **100** and **102** from rotating into one another (e.g., past the closed positions **162** and **168**). For example, the hinge pin **140** may include a protrusion that contacts a complementary protrusion on the hinge end **144** to resist further rotation of the boards **100** and **102**.

As discussed previously, coupling the boards **100** and **102** into the memory module **20** may enable installation and removal of a plurality of boards **100** and **102** and in-line memory modules **32** into the system **10**. For example, the memory module **20** may be installed into the system **10** via simultaneously engaging the board connectors **34** with the connection pins **120** and **130** of the first and second boards **100** and **102**. Although this technique may prove effective, the system **10** may also include additional features to aid in alignment of the memory module **20** to the system **10**. FIG. **7** illustrates an embodiment of guide **190** that provides for alignment of the memory module **20** during the installation and removal of the memory module **20** from the system **10**. For example, in the illustrated embodiment, the guide **190** includes a guide body **192**, a guide rail **194**, and a guide catch **196**. In the illustrated embodiment, the boards **100** and **102** are each disposed into the guide rail **194** to align the boards **100** and **102** with the complementary board connector **34**. In other words, the guide **190** enables alignment of the boards **100** and **102** to provide an aid during installation and removal of the memory module **20**. For example, the guide **190** may align the boards **100** and **102** to the connectors **34** when the memory module **20** is installed in the direction of arrow **197**, and/or removed in the direction of arrow **198**. The guide **190** can also prevent the boards **100** and **102** from misaligning with the connector **34** and from contacting other components in the system **10**. Accordingly, the guide **190** may reduce the potential for damage to the boards **100** and **102**, connectors **34**, connection pins **120** and **130**, and the like.

Further, each of the guides **190** provides for alignment of multiple boards **100** and **102**. For example, in the illustrated embodiment, the guide **190** includes a single body **192** having two rails **194** (e.g., slots). Thus, the guide **190** may be placed proximate to two board connectors **34** such that the guide **190** accepts both boards **100** and **102** from each of two memory modules **32**. In other embodiments, the guide **190** includes a version of the body **192** that provides for the alignment of any number of boards **100** and **102** and/or memory modules **32**. For example, as single guide **190** may include sixteen guide rails **194**, and, thus, be capable of supporting and aligning up to eight memory modules **20** (e.g., sixteen boards **100** and/or **102**).

The guides **190** also include features conducive to the insertion of the boards **100** and **102** into the guide rails **194**. For example, in the illustrated embodiment, each of the guide rails **194** includes the guide catch **196**. The guide catch **196** includes a geometry that helps prevent any misalignment of the boards **100** and **102** as they are inserted into the slots **194**. For example, in the illustrated embodiment, the guide catch **196** includes a chamfer or Y-shaped geometry. In other embodiments, the guide catch **196** may be widened, or the guide catch **196** may include other features to receive the boards **100** and **102**. For example, the guide catch **196** may include multiple stages that narrows into the guide rail **194**.

In one embodiment, the guide **190** is coupled to the chassis **28** to provide alignment relative to the board connectors **34**. For example, in one embodiment, the guides **190** are fastened to the chassis **28** via a screw or clip. In other embodiments, the guides **190** may be fastened relative to the board connectors **34** in other manners. For example, in one embodiment, the guide body **192** can be coupled directly to the motherboard **14**. In another embodiment, the guide body **192** is formed integral with the connector **34**. In other words, the connector **34** may include the guide **190**.

The memory module **20** may also include a latching mechanism **200** to provide for installation and removal of the memory module **20** from the system **10**. In one embodiment, the latching mechanism **200** includes a plurality of latches **202**. For example, FIG. **8** illustrates an embodiment including two latches **202** disposed on the hinge **114**. In the illustrated embodiment, each of the latches **202** includes a hinge **204**, a handle **206**, and a locking tab **208**. In operation, the latches **202** are rotated in the direction of arrows **210** to urge the boards **100** and **102** of the memory module **20** in the direction of an arrow **212**. In other words, the latching mechanism **200** may include a cam that is rotated to move the boards **100** and **102**. For example, pressing on the handles **206** in the directions of arrows **210** rotates the latches **202** about the hinge **204** such that the locking tab **208** engages a complementary locking ridge **214**. Accordingly, in certain embodiments, the board connection pins **120** and **130** are urged in the direction of the arrows **210** to engage the board connector **34**. Thus, the memory module **20** may be set and locked into the connector **34**. Similarly, other embodiments may include second locking ridges **216** that may urge the memory module **20** in the direction of an arrow **218**. For example, rotating the latches **202** in the opposite direction of the arrows **210** causes the locking tabs **208** to react against the second locking ridges **216** to urge the memory module **20** out of the connector **34**. Other embodiments may include latching mechanisms **200** in a variety of other configurations. For example, embodiments may include a single latching mechanism **200**, a latching mechanism **200** disposed on the boards **100** and/or **102**, the latching mechanism **200** integral to the connectors **34**, the latching mechanism integral to the guide **190**, and the like.

The memory module **20** may include any variety of hinge **112** configurations that enable the boards **100** and **102** of the memory module **20** to be folded. For example, in the previously discussed embodiments, the memory module **20** includes the hinge **112** coupled to the first hinge support edge **122** of the first board **100** and the second hinge support edge **132** of the second board **102**, and the hinge **112** having a generally horizontal hinge **112** orientation. FIG. **9** illustrates an embodiment of the memory module **20** that includes an alternate configuration of the hinge **112**. In the illustrated embodiment, the memory module **20** includes the hinge **112** oriented vertically. In other words, the hinge **112** is disposed along a vertical edge of the boards **100** and **102** (e.g., an edge of the boards **100** and **102** that is generally perpendicular to the edge of the boards **100** and **102** that includes the connection pins **120** and **130**). In such a configuration, the first board **100** and the second board **102** rotate in the direction of arrow **230** about the hinge pins **140**. Accordingly, the memory module **20** may be closed (folded) to enable installation of the first board **100** and the second board **102** into boards connector **34**, and the memory module **20** may be opened (e.g., unfolded) to enable access to the in-line memory modules **32** with minimal mechanical interference.

Further, certain embodiments of the memory module **20** may include features that are conducive to operation of the system **10**. For example, the memory modules **20** include cutouts that enable air to flow between components of the system **10**. For example, in the illustrated embodiment of FIG. **9**, the hinge support **142** includes cutouts **232**. The cutouts **232** provide a path for airflow in a direction generally parallel to the in-line memory modules **32**. Further, the cutouts **232** may reduce the overall weight of the module **20**, and or may reduce the cost of materials associated with the hinge **112**. Similarly, the embodiments of the memory module **20** including a horizontally oriented hinge (see FIGS. **3**-**8**) may include cutouts **232** or other features conducive to the operation of the system **10**. In addition, embodiments of the memory module **20** including the vertically oriented hinge **112** may include features similar to those described with regard to the memory module **20** including the horizontally oriented hinge **112**. For example, the memory module **20** including a vertically oriented hinge may include the latching mechanism **200**, hinge stops, and features (e.g., board edges) that enable the memory module **20** to be engaged into the guide **190**.

FIG. **10** illustrates an embodiment of the memory module **20** including an alternate layout of components. In the illustrated embodiment, the boards **100** and **102** each include in-line memory modules **32** that are disposed proximate to one another, and having an offset **250** between each of the in-line memory modules **32**. The offset **250** enables the boards **100** and **102** to be disposed proximate to one another such that the in-line memory modules **32** are disposed in an alternately-overlapping configuration. In other words the boards **100** and **102** include spacing (e.g., offset **250**) between each of the in-line modules **32** of the boards **100** or **102** such that a third in-line module **32** can be disposed between two in-line modules **32** coupled to the board **100** or **102**. For example, in the illustrated embodiment, the first board **100** and the second board **102** are folded closed, and the first board **100** is disposed lower than the second board **102** by a board offset distance **252**. In certain embodiments, the board offset distance **252** is approximately one-half of the offset **250**. Accordingly, when the memory module **20** is folded to the closed position, as illustrated, the first set of in-line memory modules **104** are staggered to overlap with the second set of in-line memory modules **106** in an alternating fashion (e.g., an in-line memory module **32** of the first set **104**, adjacent to an in-line memory module **32** of the second set **106**). In other embodiments, the offset distance **250** may be increased or decreased, and/or the board offset distance **252** may be varied to modify the spacing between the in-line memory modules **32**. Further, other embodiments may include disposing the second board **102** lower than the first board **100** by a board offset distance **252**. It should also be noted that in the illustrated embodiment, the component regions **128** and **138** are disposed such that they are generally opposing the sets of in-line memory modules **104** and **106**.

The embodiment illustrated in FIG. **10** may enable a single board design to be shared between the first board **100** and the second board **102**. For example, because the boards share components (e.g., in-line memory modules **32**, memory processors **108** and **110**, and connection pins **120** and **130**) are located in similar regions, the boards **100** and **102** may be identical. However, it should be noted, that in such an embodiment, the board connectors **34** may be disposed in opposite directions to account for the board **100** or **102** facing opposite directions. For example, FIG. **11** illustrates an embodiment of a connector layout **258** that enables the first board **100** and the second board **102** to be interchangeable. In the illustrated embodiment, the first board connector **260** is rotated 180 degrees relative to the second connector **262**. In other words, a first gap **264** in the first connector **260** is disposed at the opposite end from the second gap **266** in the second connector **262**. Accordingly, the first board **100** may be plugged into the first connector **260**, or rotated 180 degrees and plugged into the second connector **262**. As will be appreciated, this connector layout **258** may be included in other embodiments. For example, the connector layout **258** of FIG. **11** may be incorporated into the embodiments of FIGS. **3-9**, to enable the memory module **20** to be inserted as illustrated, or rotated 180 degrees and inserted. Other embodiments include various types of connectors **34**. For example, embodiments include connectors **34** with alternate keying (e.g., gaps **264** and **266**) for use with a various memory types.

The board connectors **34** may also be varied to account for the board offset distance **252**. In one embodiment, the connectors **34** may include varying heights to account for the board offset distance **252**. For example, in the illustrated embodiment of FIG. **10**, a first board connector **270** includes a height that is less than a second board connector **272**. The difference in height is the board offset distance **252**. Thus, the first board **100** disposed in the first connector **270** is offset from the second board **100** disposed in the second connector **272**. In other embodiments, the connectors **34** may be of similar heights, and the in-line memory modules **32** offset by the board offset distance **252**. For example, in an embodiment where the board connector **34** are the same or a similar height, the layout of the first board **100** and the second board **102** may not be identical (e.g., the second board **102** may include a greater distance between the second connection pins **130** and the second set of in-line memory modules **106**). The varied layout may provide the staggering between the first set of in-line memory modules **104** and the second set of in-line memory modules **106**.

Further, the hinge **112** may include features that enable the in-line memory modules **32** to include an alternate-overlapping configuration. For example, in the illustrated embodiment, the hinge **112** includes a hinge extension **274** that accounts for the board offset distance **252**. In other words, the hinge extension **274** accounts for the first board **100** being disposed slightly lower than the second board **102** due to the board offset distance **252**. Accordingly, the hinge **112** is coupled to the first board **100** via the hinge pin **140** and the hinge extension **274**, and coupled to the second board **102** via the hinge pin **140** and the hinge end **144**. Other embodiments may include variations of the hinge **112**. For example, the hinge **112** may include an L-shaped hinge support **142** (e.g., similar to the illustrated hinge support **142** and the hinge extension **274**) that couples to the first board **100** via the hinge pin **140** located proximate to the hinge support edge **122**. Further, embodiments may include a hinge **112** similar to the hinge illustrated in FIGS. **3-9**. For example, the first board **100** may have an increased height (e.g., in the direction of the illustrated hinge pin **140** of the hinge extension **274**), such that the hinge extension **274** is not used. Other embodiments include numerous variations that enable the in-line memory modules **32** to overlap in an alternating arrangement. For example, an embodiment may include a vertically oriented hinge **112**, as illustrated in FIG. **9**.

The system **10** can include any combination of the discussed embodiments. In one embodiment, the system **10** may include multiple memory modules **20** of the same or similar design, or may include a combination of the embodiments. For example, returning now to FIG. **2**, the illustrated embodiment includes four memory modules **20** including an offset and overlapping arrangement (similar to FIG. **3**), and four memory modules **20** including an alternating and overlapping arrangement (similar to FIG. **10**). In the illustrated embodiment, multiple connectors **34** are located in pairs on the motherboard **14**. For example, each equally spaced pair of connectors **34** is offset from other pairs of connectors **34**, wherein each pair supports the memory module **20**. Accordingly, multiple memory modules may be disposed across the width of the chassis **28**. As will be appreciated, each of the memory modules **20** may also include the features discussed above or any combination thereof to provide the desired performance.

What is claimed is:

1. A system, comprising:

a memory module comprising:

a first board comprising a first plurality of memory receptacles configured to support a first plurality of in-line memory modules in an overlapping relationship with a second plurality of in-line memory modules disposed on a second board, the second plurality of memory receptacles configured to support the second plurality of in-line memory modules; and

a hinge that directly couples the first board to the second board, wherein the hinge allows for movement of the first board relative to the second board about the axes of the hinge and wherein the hinge is coupled to a first hinge support edge of the first board and a second hinge support edge of the second board.

2. The system of claim **1**, wherein the hinge is disposed in a horizontal orientation relative to first and second edge connectors of the first and second boards, respectively.

3. The system of claim **1**, wherein the hinge is disposed in a vertical orientation relative to first and second edge connectors of the first and second boards, respectively.

4. The system of claim **1**, comprising a latching mechanism configured to secure the memory module to a connector.

5. The system of claim **1**, wherein the memory module comprises a clasp, a bumper, a clip, or a combination thereof.

6. The system of claim **1**, comprising a chassis, a motherboard, or a combination thereof, having a guide configured to align the first board into a mounted position.

7. The system of claim **1**, wherein the first board is configured to support at least one or more in-line memory modules.

8. The system of claim **1**, wherein the overlapping relationship comprises separate first and second groups of the first and second plurality of in-line memory modules disposed on the first and second boards, respectively, wherein the first and second groups are disposed in separate regions between the first and second boards when the first and second boards are folded together.

9. The system of claim **1**, wherein the overlapping relationship comprises a staggered arrangement of the first and second plurality of inline memory modules alternating one after another in a region between the first and second boards when the first and second boards are folded together.

10. The system of claim **1**, comprising a memory controller coupled to the first board.

11. The system of claim **1**, comprising a memory controller coupled to the second board.

12. The system of claim **1**, comprising a generic memory interface device coupled to the first board.

13. The system of claim **1**, comprising a generic memory interface device coupled to the second board.

14. The system of claim **1**, comprising a computer system having the memory module, a processor, a disk drive, a hard drive, a video card, an audio card, a motherboard, a monitor, a printer, or a combination thereof.

15. A system, comprising:

a circuit board comprising a first board connector and a second board connector configured to support first and second memory boards comprising first and second plurality of memory receptacles configured to support first and second in-line memory modules respectively, overlapping with one another, wherein the first and second memory boards are directly coupled to a first hinge support edge and a second hinge support edge of a hinge that allows for movement of the first memory board relative to the second memory board about the axes of the hinge, wherein the first and second memory boards are disposed between the hinge and the first and second board connectors.

16. The system of claim **15**, further comprising:

a third board connector and a fourth board connector configured to support third and fourth memory boards having in-line memory modules overlapping with one another;

wherein the first board connector and the second board connector are separated by a first distance from one another on the circuit board, and the third board connector and the fourth board connector are separated by the first distance from one another on the circuit board, the first board connector and the third board connector are separated by a second distance that is greater than the first distance, and the second board connector and the fourth board connector are separated by the second distance from one another.

17. The system of claim **15**, comprising the first memory board disposed in the first board connector and configured to support the first plurality of in-line memory modules in an overlapping relationship with the second plurality of in-line memory modules disposed on the second board disposed in the second board connector.

18. The system of claim **15**, comprising a first guide configured to align the first memory board to the first board connector, a second guide configured to align the second memory board to the second board connector, or a combination thereof.

19. The system of claim **15**, wherein the first board connector and the second board connector comprise different heights relative to the circuit board.

20. The system of claim **15**, wherein the orientation of the first board connector is rotated 180 degrees from the orientation of the second board connector.

21. A system, comprising:

a memory module comprising:

a first memory board comprising a first plurality of memory receptacles configured to support a first plurality of memory modules;

a second memory board comprising a memory receptacles configured to support a second plurality of memory modules in an overlapping relationship with the first plurality of memory modules; and

a hinge that directly couples the first board to the second board, wherein the hinge allows for movement of the first board relative to the second board about the axes of the hinge and wherein the hinge is coupled to a first hinge support edge of the first board and a second hinge support edge of the second board; and

a circuit board comprising a first board connector and a second board connector configured to support the first memory board and the second memory board, wherein the first and second memory board are disposed between the hinge and the first and second board connectors.

22. The system of claim **21**, wherein the hinge is disposed in a horizontal orientation relative to first and second board connectors.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	: 8,537,563 B2	Page 1 of 1
APPLICATION NO.	: 11/859601	
DATED	: September 17, 2013	
INVENTOR(S)	: Brian T. Purcell et al.	

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification

In column 5, line 36, after “includes” insert -- a --.

In column 5, line 40, delete “tow” and insert -- two --, therefor.

In column 5, line 45, delete “substantial” and insert -- substantially --, therefor.

In column 5, line 50, delete “20-1, 20-1.” and insert -- 20-1, 20-2. --, therefor.

In column 5, line 57, after “board” insert -- 100 --.

In column 5, line 66, delete “includes” and insert -- include --, therefor.

In column 6, line 1, delete “13” and insert -- 13, --, therefor.

In column 6, line 2, delete “34-A 34-B 34-C 34-D” and
insert -- 34-A, 34-B, 34-C, 34-D --, therefor.

Signed and Sealed this
Fourth Day of February, 2014

Michelle K. Lee

Michelle K. Lee
Deputy Director of the United States Patent and Trademark Office